Innovation through R&D activities in the European context: Antecedents and consequences

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Abstract

Despite the fact that the determinants and the consequences of R&D activities have been extensively studied in previous research, further efforts to integrate disparate streams of literature might bring new insights into innovation decision-making by firms. In particular, this article studies the simultaneous effects that a set of factors (at both company and environmental levels of analysis) have on R&D activity, which explain firm growth. A two-stage probit least squares (2SPLS) estimation is applied to data from the EU-EFIGE/Bruegel-UniCredit dataset for seven European countries for the years 2007-2009. The main findings show that not all the R&D determinants lead to firm growth. In particular, R&D activities are affected by the employment of a significant number of foreign executives, a higher percentage of employees with fixed-term contracts, appropriate labour regulations and access to employees who have received external training, all of which are positively related to firm growth. Based on these results, policy and practical implications to improve firms' performances are discussed.

Keywords*:* R&D management, Firm growth, Innovation, Institutional Economics, Resource-based theory.

1. Introduction

It has been recognised that investments in R&D activities can have a positive effect on firm performance and on economic growth (Aghion and Howitt 1992; Grossman and Helpman 1991). For this reason, a significant number of studies have examined how R&D activities are influenced by several factors, such as: a firm's industry (Scherer 1984); public policy instruments (Becker 2015); national institutions (Judge et al. 2015); access to informal networks (Reagans and McEvily 2003); corporate strategy (Baysinger et al. 1991); firm size (Revilla and Fernández 2012); access to company resources (Del Canto and Gonzalez 1999) and organizational slack (Alessandri and Pattit 2014); CEO characteristics and leadership style (Barker and Muller 2002); and employees' absorptive capacity and knowledge (Kang et al. 2017); among others. Although the literature is diverse, two different but strong streams of research on the antecedents of R&D activity are highlighted, namely, economics and management (Griffiths and Webster 2010; Teece 2018). On the one hand, from an economic perspective, the emphasis tends to be placed on the effect of external factors such as industry characteristics or competitive environment (Wang 2007). On the other hand, the management and business literature has been more focused on companies' internal variables, such as a firm's strategy and human resource practices (Stock et al. 2014).

The question that still persists for scholars, policy makers and managers is whether the amount of public and private resources invested in creating R&D activities and projects exerts profitable and successful innovations which help companies grow (Markham et al. 2010). As it is well known, innovative activities are developed under high risk and uncertainty (Branscomb et al. 2001). Auerswald and Branscomb (2003) have discussed how some costly projects do not succeed because no commercial applicability is found in the new invention, which, in turn, affects the growth goals of firms. This problem, therefore, is latent and implies

that firms must make great endeavours in recognising the appropriate organisational structure, both ordinary and dynamic capabilities, activities, structures, strategies and resources, such that innovation takes place in order for the firm to gain competitiveness (Teece 1986).

Extant literature recognises the problem of progressing scientific discovery from laboratory to market (Moultrie 2015) as "companies struggle to convert technology concepts into products" (Markham et al. 2010: 402). Few research studies have made significant attempts to address this phenomenon. For instance, there are works that have used a holistic approach to study both the determinants of R&D activity and its subsequent consequences on sales, profits, number of employees or new product launches (Choi et al. 2016; Oura et al. 2016; Stock et al. 2014; Wang 2007; Wang and Dwi Lestari 2013); however, these studies recognise limitations and certain relevant areas could be explored further. First, previous research using a holistic approach considers mostly company- and individual-level factors (Oura et al. 2016). Therefore, from this perspective, the role of environmental antecedents for R&D has not been researched in depth (Feldman 2014). In particular, the effect of formal institutions (i.e., regulations) has not been studied quantitatively from an antecedents and consequences perspective (Martin 2016; Patriotta and Siegel 2019). This is a relevant omission because it means that the analysis of the barriers and drivers to innovation through R&D activities is not complete. Specifically, the literature suggests further analysis on factors such as labour regulations and access to highly skilled employees, because both might be relevant for R&D activities as they may foster or hamper the recruitment process of qualified workers needed for the invention process (Bornay-Barrachina et al. 2012; Kleinknecht et al. 2014). Secondly, there is limited evidence of the complementary effects that both internal and environmental determinants have on R&D activities (directly) and on firms' performance (indirectly), which limits our understanding of this phenomenon (Feldman 2014). A more

complete picture of how various factors condition R&D activity, but also how they subsequently influence firm performance, could enhance our knowledge about the type of organisational resources, human capital practices and public policies that lead to successful R&D.

The main objective of this article, therefore, is to study the simultaneous effects that a set of factors (at the company and environmental levels of analysis) have on R&D activity, which may explain firm growth. This study applies a two-stage probit least squares (2SPLS) estimation, using data from the EU-EFIGE/Bruegel-UniCredit. Based on Resource Based Theory (Barney 1991) and Institutional Economics (North 1990), the results show how a set of two different internal resources (employment of foreign executives and the percentage of fixed-term contracts among employees) and two external institutional determinants (country labour regulations and specific training outside the firm) influence R&D activities in Europe. In addition, their subsequent influence on firms' growth is also confirmed. This allows us to have a more complete understanding of innovation through R&D, which has implications, both from a theoretical and practical point of view.

Our study contributes first to the literature that explores antecedents and consequences of R&D activities as mechanisms for intrapreneurship and corporate entrepreneurship behaviours (Baden-Fuller 1995; Hughes and Mustafa 2017; Turro et al. 2014). This is, our model provides an enhanced understanding about which specific R&D determinants lead to firm growth and job creation. Hence, we contribute by showing how investments in some specific R&D determinants might be particularly appropriate if companies want to grow. This is a relevant implication because previous literature does not agree about under which circumstances R&D activities lead to firm growth (Lamperti et al. 2017). Hence, although some companies spend significant amounts of resources on R&D and policy makers design policies to foster these

types of activities, their efforts do not necessarily lead to better firm performance (Ahn et al. 2018; Coad and Rao 2008). Second, our findings also contribute to literature on the effect that internal resources (company related) and environmental institutional determinants have for R&D activities. Particularly, we contribute to the literatures on Resource Based Theory (Barney 1991) and Institutional Economics (North 1990) since the relevant role of key resources and formal institutions had not been studied in the context of considering both antecedents and consequences. In this regard, drawing on the intersection between (institutional) economics and management, our results may be useful to dive into the policy discussion about gaining knowledge from immigration and international relations (Kitching et al. 2009). We show that both, external training and workers from overseas are sensitive strategies that generate innovation and, at the same time, spur firm growth. In addition, at the managerial and strategic levels, our results might be helpful for those managers searching for new markets at the local or international level. Consistent with the extant literature, the adoption of innovations may respond to both external and internal factors (Damanpour et al. 2018), preparing firms to create or enter into new markets.

Apart from this introduction, the paper is structured as follows. In the second section, we review the literature on innovation and entrepreneurial activities through R&D, as well as present the hypotheses of the research. Next, we detail the methodology of the study. Subsequently, the findings of the study are presented, together with some checks for robustness. These results are then discussed. Finally, the last section provides conclusions and suggests some limitations and future research lines.

2. Literature review and hypotheses

From an internal determinants' perspective, extant research has highlighted that human

capital attributes may be viewed as a valuable company resource (Barney 1991; Riley et al. 2017). Hence, employees with higher pools of human capital should be more capable of both recognising and exploiting new business opportunities (Davidsson and Honig 2003). In this regard, having cultural diversity and different backgrounds among managers (hence, wider and higher human capital) should have a positive effect on a firm's capacity to adapt to new changes and to innovate. This is, managers with experience in other companies or countries, may have a wider vision of strategic decision-making, use a broader variety of information sources, have a better understanding of foreign markets (Musteen et al. 2014) and overall, have more widely differentiated capabilities (Lee and Park 2006). In addition, managers with these characteristics tend to make more changes in structure, procedures, and people, than chief executives promoted from within the firm (Escriba-Esteve et al. 2008). Cultural (and knowledge) diversity can positively affect the firm's speed of absorption of external knowledge, which leads to greater R&D investments (Moreira et al. 2018). In this regard, R&D expenditure is one of the innovation indicators that is more strongly related to different forms of firm growth (Bianchini et al. 2018; Hodges and Link 2019) even when companies compete in non-high-tech sectors (Booltink and Saka-Helmhout 2018).

The role of temporary contracts on innovation outcomes represents another key internal resource (also related to human capital) whose effect remains unclear (Zhou et al. 2011). Flexibility is considered a fundamental factor if companies want to respond quickly to technological changes and to new business opportunities (Altuzarra and Serrano 2010). Therefore, companies need not only to have skilled employees but also flexibility to manage the workforce. This is, investments in innovation and R&D often require work reorganisation; hence, those companies that have less firing restrictions should be more able to adapt to those changes (Saint Paul 2002), particularly, in contexts of high uncertainty (Ghignoni et al. 2018).

It is suggested that an inflow of new employees reduces the risk of having entrenched (and, therefore, less entrepreneurial and creative) employees in secure jobs (Kleinknecht et al. 2014). Similarly, flexibility enables an easier replacement of less productive employees by more productive ones (Zhou et al. 2011). Based on the above, the following hypotheses are posed:

> Hypothesis 1a: The employment of foreign executives in the firm makes the development of innovation through R&D more likely, which enables an increase in the firm's growth.
>
> Hypothesis 1b: The engagement of employees using fixed-term contracts makes the development of innovation through R&D more likely, which enables an increase in the growth of the firm.

From an external determinants' perspective, the formal institutional framework (North 1990) has extensively been considered to play a fundamental role as it stimulates (or constraints) innovation in companies (Puffer et al. 2010). Hence, policy makers are aware of the importance of creating an environment that supports R&D activities (Becker 2015; von Zedtwitz et al. 2015). In this respect, the labour market is part of the formal institutional framework and it is relevant for R&D activity. Some of the most studied labour market aspects include, among others, strong trade unions, access to relevant social benefits and high minimum wages (Kleinknecht et al. 2014). Overall, a proper labour regulation accelerates the transition of employees to new and growing sectors and increases the probability that individuals end up working in those positions where they can contribute the most and therefore be most productive. This is, in more flexible markets, resources tend to be allocated more efficiently and therefore, investments increase (Di Cintio and Grassi 2017). In this context, investments in R&D tend to lead to different types of firm growth (Ruiqi et al. 2017; Stam and

Wennberg 2009).

Research explains how a simplified labour market could serve to obtain the necessary resources needed to develop new innovative projects more easily (Begley et al. 2005). In this regard, external training and education are also part of the formal institutional environment and contribute to provide the wide range of skills needed to improve the companies' innovation capacity (Gonzalez et al. 2016). Consistent with this, private R&D benefits from geographically localised knowledge spillovers and from access to highly skilled human capital (Becker 2015). Also, innovative employees have a higher level of education than people who do not (Bowen and Hisrich 1986). Training can increase the distribution of knowledge across employees and facilitate the development and reconfiguration of existing capabilities (Thornhill 2006). Therefore, as employees acquire specific human capital resources and skills from training programmes, experiences and learning processes (Guerrero and Peña 2013), it is considered necessary that the company offers specific training and refresher courses to their workers to implement and develop innovative projects (Hayton and Kelley 2006). Overall, the existence and intensity of this effect on performance may be different depending on various company or environmental characteristics which may simultaneously influence the likelihood of engaging with R&D activities and the effects on firm performance (Riley et al. 2017; Teirlinck 2017). Therefore, we propose the following hypotheses:

> Hypothesis 2a: Higher labour market restrictions make the development of innovation through R&D less likely, which leads to a reduction in firm growth.
>
> Hypothesis 2b: Training outside the firm makes the development of innovation through R&D more likely, which leads to an increase in firm growth.

3. Methodology

The current study uses the EU-EFIGE/Bruegel-UniCredit dataset (Altomonte and Aquilante 2012). This survey, released in 2010, includes cross-sectional information about manufacturing companies across seven European countries (Austria, France, Germany, Hungary, Italy, Spain and the UK) for the years 2007-2009. The dataset includes information for 14,759 European firms, distributed as follows: 3,021 in Italy; 2,973 in France; 2,935 in Germany; 2,832 in Spain; 2,067 firms in the UK; 488 firms in Hungary; and 443 in Austria. The sample selected in each country has been designed to be representative of the manufacturing structure (stratification by industry, region and firm size). In this regard, the survey excludes firms smaller than 10 employees. In addition, the EFIGE dataset is fully comparable across countries, as it has been obtained from responses to the same questionnaire administered over the same time span (January to May, 2010). Altomonte and Aquilante (2012) provide further details about the survey design, sampling, validity and so on. The data have been validated through different studies in the area of innovation. These articles are summarised in Table 1.

Table 1. Articles in the area of innovation that use the EU-EFIGE/Bruegel-UniCredit dataset

Article	**Main research question/objective**	**D.V.**	**I.V.**
Aiello and Ricotta (2016)	"How much of the difference in firm performance can be attributed to individual heterogeneity and how much of this difference reflects territorial conditions around Europe?"	Total Factor Productivity	Groups by Countries, Sectors
Aristei, Sterlacchini, and Venturini (2017)	"1) Did public subsidies to R&D increase or, at best, avoid a reduction in business research more severe than the one recorded in 2009 in the major countries of the EU? 2) Were there significant differences across EU countries in the effectiveness of R&D subsidies?"	R&D subsidies	Age, size, holder, quality certification, Foreign/National, investment, graduated employees, patent, bank credit, regional R&D intensity, regional TFP
Aristei, Vecchi, and Venturini (2016)	"To investigate the determinants of firms' decision to cooperate in R&D with universities and the intensity of the cooperation effort, in relation to the engagement in inter-firm R&D collaborations."	R&D cooperation	Ownership structure, management practices, workforce profile, international activities, financing and banking relationships, market structure, pricing behaviour

Calia, D'Attoma, and Pacei (2016)	"Do European manufacturing firms that undertake offshoring, innovation or both benefit from higher productivity and profitability?"	Offshoring, Innovation	Age, country, size, Foreign/National, sector, (local/international), export intensity, capital intensity, employees, R&D investment intensity
Carboni (2017)	"To estimate the effect of participating in a public programme in investment and R&D expenditure in a sample of European manufacturing companies	Incentives to investment, incentives to R&D	Investment over sales, research over sales
Carboni and Medda (2018)	"To provide an empirical investigation of the mechanism through which R&D influences export and tangible investment decisions"	R&D, export, investment	Employees, age, willingness of more credit, incentives for R&D, investment with internal sources, Foreign/National groups, country, sector
Cosci, Meliciani, and Sabato (2016)	"To what extent a banker able to gather relevant soft information about prospects and the creditworthiness of a firm may stimulate the firm's innovation activity?"	Product and/or process innovation	Banks, long-lasting relation to banks, balance sheet, venture capital, public funds, tax incentives, size, age, fixed assets, export
Fassio (2017)	"To analyze the effect of exporting activity on the innovative performances of firms."	Process innovation, brand new product innovation	Exports, foreign demand effect, technology learning effect
Medda (2018)	"To estimate the impact that external sources of R&D may have on different kind of innovations (product and process), differentiating between R&D supplied by universities and other research centers, on one side, and other companies, on the other."	R&D expenditure	Employees, age, export, part of group, lack of appropriate financing, country

Note: D.V.: Main dependent variable(s); I.V.: Main independent variable(s).

In general, the questions refer to 2008, although some relate to information in 2009 and the years previous to 2008. This is done to account for the effects of the crisis as well as the dynamic evolution of firms' activities. Finally, the data contain additional information that allows us to go beyond balance sheet information to address other relevant matters related to the relationship between innovation through R&D and firm performance. In this regard, the dataset also provides information on firm characteristics and activities; the variables are divided into six sections: proprietary structure of the firm; structure of the workforce; investment, technological innovation and R&D; internationalization; finance; and market and pricing. Based on this structure, we pay particular attention on those variables that enable us to

capture internal characteristics often associated with human capital, and those external factors related to certain regulations and market characteristics that explain, first innovation through R&D, and second, firm performance.

3.1. Dependent variables

We are interested in knowing how R&D activities and firm performance are recursively linked. Thus, our first dependent variable consists of measuring *innovation through R&D*. Although this is a limited proxy, there are studies that still use R&D to discuss innovative activities (cf. Link and Scott 2019; Patlibandla and Peterson 2002). These works explain that R&D involves staff with certain technical knowledge that are expected to innovate either methods or products. It is an investment that can bring return to the firm throughout competitiveness and new knowledge that is transferred from universities, laboratories, etc. (Amorós et al. 2019; Cunningham et al. 2019; Guerrero and Urbano 2019). On these bases, we have a binary variable which takes the value 1 if the firm has more than 1% of employees involved in R&D activities and more than 1% of Entrepreneurs/executives (included middle management) familiar or not of own firm; and 0 otherwise. Previous studies in entrepreneurship and R&D literature have used similar binary dependent variables (Altomonte et al. 2013; Arenius and Minniti 2005).

Our second dependent variable comprises a traditional measure of *firm growth*, which is related to the size of the firm. Despite that there exist different alternatives to measure performance, it is suggested that sales, assets and employment are highly correlated, so they could substitute each other (Wiklund and Shepherd 2005). The dataset enables us to understand entrepreneurship and innovative behaviour within the company and its possible relationship with the firm's achievements (e.g., annual turnover in 2008, number of employees,

etc.).Therefore, we approach to firm growth by capturing the total number of employees of firms in the home country in 2008.

3.2. Internal factors as independent variables

In order to test the first set of hypotheses, which are related to human capital variables, we have used *foreign executives*. This variable is measured through a dummy that takes the value 1 if the firm has more than 1% of Foreign Executives (included middle management); and 0 otherwise. The reasoning behind this proxy regards to the knowledge that can be shared throughout socialization processes between local and foreign workers. Hausmann (2016) explains that a way to gain competitiveness consists of recruiting people from overseas to learn different processes and ways of doing things. Indeed, Hausmann and Neffke (2019) show how workers mobility helps to expand knowledge frontiers, which is observed through new industries in the economy.

In order to achieve such an expansion through foreign workers, it is also important that the firm offers appealing contracts, which match the experience and salary of the worker. In this sense, we have captured *fixed-term contract* as the percentage of employees that have worked with fixed-term contract in 2008 (variable transformed into natural logarithm). Authors such as Brown and Sessions (2005) suggest that this behaviour within firms might penalise workers with same level of education compared to those having permanents contracts. However, Boockmann and Hagen (2008) and Hagen (2002) suggest that variables like this might capture a sort of incentive firms apply to increase workers' performance. These authors explain that workers are tempted to enter into permanent contracts, so a good internal competition might benefit the company through different innovations workers can come up with.

3.3. External factors as independent variables

According to Teece et al. (2007), firms should combine internal characteristics (or capabilities) with external factors that can bring opportunities or challenge, which serve firms to learn from. In order to cover some aspects that are external to the company, we have used *labour regulations*, which is measured through a binary variable that takes the value 1 if the firm has considered labour market regulations as a main factor preventing an appropriate firm performance; and 0 otherwise. Although this is a firm's perception, other authors have provided evidence on how expectations coming from certain regulations might affect firms (cf. Krasniki and Desai 2016). Basically, firms modify their decisions according to what they think of supportive policies or barriers imposed by governments (Brown et al. 2017; Lajqi and Krasniki 2017).

Another external variable has to do with the knowledge existing out of the firm that can be acquired through strategies related to *formal training*. Acs et al. (2013) and Braunerhjelm et al. (2018) explain that knowledge can be learnt through entrepreneurs either creating new ventures or working for SMEs. We approach to this external knowledge by using a binary variable which takes the value 1 if the employees have participated in formal training programs outside the firm; and 0 otherwise. Coad et al. (2016) and Storey (2004) have used similar variables, in which the training has come from banks or other companies, respectively. Accordingly, these authors find that training is a good variable that explains entrepreneurship and firm performance.

3.4. Control variables

To control for unobservable characteristics within the firm, we use *gender of CEO* (equal to 1 if male; otherwise 0); *workforce variation* (equal to 1 if the firm has perceived workforce reduction or increase; and 0 otherwise)*; managerial experience* (equal to 1 if the firm has had any executive working abroad at least 1 year; and 0 otherwise); *external financing* (level of external financing dependency perceived in the industry of firm --variable transformed into natural logarithm); and *R&D investment* (average percentage of the total turnover that the firm has invested in R&D in the last three years (2007-2009) –variable transformed into natural logarithm). From this perspective, some previous studies have indicated that women's participation rates in entrepreneurship are lower than the rates for men (Arenius and Minniti 2005). Similarly, changes in the workforce and the number of employees have also been highlighted as potential factors influencing entrepreneurial activities (Barbosa and Eiriz 2011). In addition, different types of previous experiences might have an effect on the likelihood of engaging in R&D activities (Di Guardo and Harrigan 2016). Finally, access to external finance has been extensively considered to play a key role in the development of innovative outcomes (Chang and Shih 2004).

To control for certain aspects that can also affect firm performance (Visintin and Pittino 2014; Vohora et al. 2004;), the variables analysed were the *age* of the organisation (those firms with 6–20 years of operation and those with less than 6 years are equal to 1; 0 otherwise) and *industry types* (i.e., traditional, exhibiting economies of scale, and specialised), which are represented by dummy variables as well. Regarding country-specific effects, in addition to labour regulations and workforce variation which capture regulatory and some market dynamics, we also included country fixed effects in the equations. As we are using cross-sectional data, the inclusion of other variables at the country level might be useless as their influence can be observed by the constants representing each fixed-effect. It is also important

to notice that although some authors have used firm size as a control variable explaining firm performance (Baum and Wally 2003; Burghardt and Helm 2015; Coad and Rao 2008; Delmar et al. 2003; among others), we avoided this measure as some collinearity problems with the firm growth proxy occurred. Table 2 provides a summary of the variables used in the study.

Table 2. Description of variables

Eq. 1	**Variable**	**Description**
Dependent variables	Innovation through R&D	Dummy variable takes the value 1 if the firm has more than 1% of employees involved in R&D activities and more than 1% of Entrepreneurs/executives (included middle management) familiar or not of own firm; and 0 otherwise.
Independent variables:	Foreign executives	Dummy variable takes the value 1 if the firm has more than 1% of Foreign Executives (included middle management); and 0 otherwise.
	Ln % employees with fixed-term contract	Percentage of employees that have worked with fixed-term contract in 2008.
	Labour market regulations	Dummy variable takes the value 1 if the firm has considered labour market regulations as a main preventing an appropriate firm performance; and 0 otherwise.
	External training	Dummy variable takes the value 1 if the employees have participated to formal training programmes outside the firm; and 0 otherwise.
Control variables	Gender of CEO	Dummy variable takes the value 1 if male; and 0 otherwise.
	Any variation of workforce	Dummy variable takes the value 1 if the firm has perceived workforce reduction or increase; and 0 otherwise.
	Managerial experience	Dummy variable takes the value 1 if the firm has had any executive that worked abroad at least 1 year; and 0 otherwise.
	Ln Dependency of external financing of industry sector	Level of external financing dependency perceived in the industry of firm.
	Ln % of investment in R&D from total turnover	Average percentage of the total turnover that the firm has invested in R&D in the last three years (2007-2009)
Eq. 2	**Variable**	**Description**
Dependent variable	Ln Firm growth	Total number of employees of your firm in the home country in 2008.
Independent variables	Innovation through R&D	Dummy variable takes the value 1 if the firm has more than 1% of employees involved in R&D activities and more than 1% of Entrepreneurs/executives (included middle management) familiar or not of own firm; and 0 otherwise.
Control variables	Between 20 and 6 years of operation	Dummy variable takes the value 1 if the firm has operated between 6 and 20 years since the establishment; 0 otherwise.
	Less than 6 years of operation	Dummy variable takes the value 1 if the firm has operated less than 6 years since the establishment; 0 otherwise.

	Traditional industries	Dummy variable takes the value 1 if the firm corresponds to the traditional industries according to Paviit classification on the basis of original NACE code of firm (3-digits); 0 otherwise.
	Economies of scale industries	Dummy variable takes the value 1 if the firm corresponds to the economies of scale industries according to Paviit classification on the basis of original NACE code of firm (3-digits); 0 otherwise.
	Specialised industries	Dummy variable takes the value 1 if the firm corresponds to the specialised industries according to Paviit classification on the basis of original NACE code of firm (3-digits); 0 otherwise.

3.5. Econometric technique

We used a two-stage probit least squares (2SPLS) estimation (Keshk et al. 2004; Maddala 1983), based on a dummy variable version of two-stage least squares (2SLS), as the estimation strategy. The set of equations are stated as follows:

$$P(RD_i = 1) = f(R_i, I_i, CV_i) \quad (1)$$

$$FG_i = f(\widehat{RD}_i, x_i) \quad (2)$$

where RD_i corresponds to innovation through R&D, R_i refers to companies' resources and capabilities, I_i represents institutions and CV_i represents the control variables for Eq. (1). Regarding Eq. (2), FG_i is firm growth, RD_i is innovation through R&D and x_i denotes the control variables for this equation. All these variables pertain to each organisation *i*.

The estimation follows a two-stage process with an additional step of standard error correction to avoid heteroscedastic results. Eq. (1) is estimated with probit and Eq. (2) using ordinary least squares (OLS); the predicted values ($\widehat{RD}_i$ and $\widehat{FG}_i$) from each model are obtained throughout the second stage. In this step, the original endogenous variable in Eq. (1) is replaced by $\widehat{RD}_i$. Finally, the procedure ends with the correction of standard errors to guarantee the

efficiency of the estimated equations. Using the *cdsimeq* command developed by Keshk (2003) in Stata, all these estimations were executed automatically.

Given the research objective, potential endogeneity between the dependent variables (*firm growth* and *innovation through R&D*) could exist. It is likely that innovation through R&D is driven by increasing firm performance and this type of entrepreneur contributes to higher firm growth as a result of new product and service creation. Innovation through R&D only accounts for a small percentage in most countries and this may attenuate its feedback into firm performance. To overcome this situation, we focused on instrumenting innovation by taking into account human capital as well as institutional factors.

4. Results

4.1. Main results

Table 3 provides a summary of the descriptive statistics for the variables we studied. Table 3 shows that, in our sample, on average, 72.7% of companies devote more than 1% of their employees and executives to R&D activities. In terms of firm growth, on average, firms across the sample have 65.09 workers.

Table 3. Descriptive statistics

	Variables	N	Mean	Std. Dev.	Min	Max
1	Innovation through R&D	14759	0.727	0.445	0	1
2	Foreign executives	14759	0.219	0.413	0	1
3	Fixed term contract	14759	0.039	0.194	0	1
4	Labour regulations	8685	2.982	2.239	0	23.026
5	External training	12444	0.190	0.392	0	1
6	Gender of CEO	14526	1.161	2.327	0	23.026
7	Workforce variation	14759	0.367	0.482	0	1
8	Managerial experience	14759	0.922	0.267	0	1
9	External financing	14759	0.584	0.493	0	1
10	R&D investment	7403	1.429	1.148	0	23.026

11	Firm growth	14759	65.095	102.045	10	500
12	6 to 20 years	14759	0.352	0.478	0	1
13	Less than 6 years	14759	0.071	0.256	0	1
14	Traditional industries	14759	0.477	0.499	0	1
15	Economies of scale industries	14759	0.252	0.434	0	1
16	Specialised industries	14759	0.181	0.385	0	1

Note: N.: Number of observations, Std. Dev.: Standard deviation, Min.: Minimum value, Max.; Maximum value.

In addition, the correlation analysis in Table 4 shows several significant correlations at the 90% level for some of the variables studied, however, the subsequent multicollinearity analysis shows that this is not a problem. Specifically, we calculated the VIF value for Eq. (1), which is 1.02, while for Eq. (2) it is 1.95. Thus, excessive multicollinearity is not affecting our results significantly. Particularly, the correlation analysis displays that our variables of interest (i.e. foreign executives, fixed terms contract and external training) are positively correlated to innovation through R&D; whilst labour regulation goes in opposite direction. Table 4 also shows that innovation through R&D and firm growth are positively correlated. These results are consistent with our initial expectations.

Table 4. Correlation matrix

Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1 Innovation through R&D	1							
2 Foreign executives	**0.097**	1						
3 Fixed term contract	0.012	0.010	1					
4 Labour regulations	**-0.087**	**-0.025**	**-0.069**	1				
5 External training	**0.062**	-0.007	-0.011	**-0.033**	1			
6 Gender of CEO	**0.070**	0.012	0.015	**-0.027**	0.019	1		
7 Workforce variation	**0.071**	**0.024**	**0.036**	0.019	0.014	0.012	1	
8 Managerial experience	**0.153**	**0.209**	0.020	**-0.040**	**0.031**	**0.042**	**0.060**	1
9 External financing	**0.037**	**0.029**	**0.056**	**-0.064**	**0.033**	-0.001	0.016	**0.040**
10 R&D investment	-0.002	**0.042**	0.025	0.005	0.014	-0.013	**-0.053**	**0.033**
11 Ln Firm growth	**0.251**	**0.259**	**-0.091**	**-0.055**	-0.006	**0.078**	**0.143**	**0.324**
12 6 to 20 years	-0.006	**-0.031**	**0.036**	-0.022	0.018	-0.003	0.018	**-0.033**
13 Less than 6 years	0.015	-0.004	0.016	-0.022	-0.006	-0.010	**0.032**	0.010
14 Traditional industries	**-0.137**	**-0.068**	**0.040**	**0.048**	**-0.047**	**-0.043**	-0.014	**-0.122**
15 Economies of scale industries	**0.072**	**0.029**	-0.020	-0.021	-0.009	0.019	0.012	**0.056**
16 Specialised industries	**0.061**	**0.034**	-0.017	**-0.035**	**0.035**	**0.033**	0.016	**0.054**
	9	**10**	**11**	**12**	**13**	**14**	**15**	**16**

8	International experience								
9	External financing	1							
10	R&D investment	0.027	1						
11	Ln Firm growth	**0.032**	**-0.104**	1					
12	6 to 20 years	-0.007	**0.047**	**-0.129**	1				
13	Less than 6 years	0.009	0.017	**-0.044**	**-0.203**	1			
14	Traditional industries	**-0.028**	**-0.070**	**-0.130**	0.005	0.006	1		
15	Economies of scale industries	-0.001	0.001	**0.091**	-0.015	-0.008	**-0.555**	1	
16	Specialised industries	**0.044**	0.025	**0.035**	0.005	-0.006	**-0.448**	**-0.273**	1

Correlations in bold are significant at $p < 0.10$.

Furthermore, to address the possibility of heteroscedasticity and autocorrelation among observations pertaining to the same company, corrected standard errors were estimated (Keshk 2003). The 2SPLS regression analysis is presented in Table 5, in which we report the estimated coefficients, the marginal effects (probit models) and corrected standard errors in parentheses for all models. All the models are highly significant ($p \leq 0.000$). Although the analysis is based on 2SPLS results, for comparison reasons, we used three additional estimation strategies: the linear probability model (not accurate given the dummy nature of the dependent variable in Eq. (1)), the probit model (appropriate for Eq. (1), but does not take into account the simultaneity issue), and linear regression for Eq. (2) only. Thus, Model 1 presents the regression results for company and environmental factors affecting the development of innovation via R&D in a linear probability model performed through OLS (Eq. 1). Model 2 assesses the same variables using probit estimation. Model 3 shows the results of analysis only for firm growth analysis (Eq. 2). Model 4 displays the results for both equations using the entire set of variables analysed in this paper. Given that some variables have missing values, the sample varies across models.

Table 5. Estimation results of simultaneous equation model

	(1)	(2)		(3)	(4)	
	Innovation through R&D	Innovation through R&D			Innovation through R&D	
		Estimation	dy/dx		Estimation	dy/dx
Foreign executives	0.133***	0.831***	0.157***		0.381**	0.088**
	(0.015)	(0.155)	(0.017)		(0.182)	(0.035)
Ln % employees with fixed-term contract	0.006***	0.028*	0.008*		0.046***	0.012***
	(0.002)	(0.016)	(0.004)		(0.013)	(0.004)
Labour market regulations	-0.079***	-0.271***	-0.078***		-0.187***	-0.053***
	(0.018)	(0.057)	(0.018)		(0.060)	(0.018)
External training	0.038***	0.136***	0.036***		0.174***	0.046***
	(0.013)	(0.051)	(0.013)		(0.052)	(0.014)
Gender of CEO	0.138***	0.431***	0.135***		0.249**	0.073**
	(0.030)	(0.088)	(0.031)		(0.096)	(0.031)
Any variation of workforce	0.057***	0.208***	0.058***		0.122**	0.033**
	(0.014)	(0.050)	(0.014)		(0.054)	(0.015)
Managerial experience	0.107***	0.425***	0.108***		0.089	0.023
	(0.013)	(0.057)	(0.013)		(0.096)	(0.025)
Ln Dependency of external financing of industry sector	0.005**	0.024+	0.007+		0.019	0.005
	(0.002)	(0.015)	(0.004)		(0.013)	(0.003)
Ln % of investment in R&D from total turnover	-0.005	-0.021	-0.006		0.030	0.008
	(0.006)	(0.022)	(0.006)		(0.025)	(0.007)
Ln Firm growth					0.457***	
					(0.104)	
Constant	0.571***	0.086			-1.517***	
	(0.034)	(0.104)			(0.379)	

(Pseudo) R^2	0.057	0.061		0.067
Probability		0.810		0.811
Log likelihood		-1696.465		-1686.921
LR X^2				241.07
			Ln Firm growth	**Ln Firm growth**
Innovation through R&D			0.515***	1.045***
			(0.015)	(0.089)
Between 20 and 6 years of operation			-0.287***	-0.343***
			(0.016)	(0.061)
Less than 6 years of operation			-0.286***	-0.432***
			(0.029)	(0.112)
Traditional industries			-0.195***	0.205*
			(0.030)	(0.107)
Economies of scale industries			0.020	0.119
			(0.033)	(0.106)
Specialised industries			-0.055+	0.096
			(0.034)	(0.110)
Constant			3.405***	3.095***
			(0.031)	(0.134)
Country fixed-effects	No	No	No	Yes
Observations	3531	3531	14759	3531
R^2			0.095	0.274

+ p = 0.1, * p < 0.10, ** p < 0.05; *** p < 0.01.

Note: Model 1 is estimated through linear probability model (OLS) with robust standard errors, Models 2 and 3 are estimated through probit and OLS with robust standard errors, respectively; while model 4 is estimated using 2SPLS, which have corrected standard errors (in parentheses).

Hypothesis 1a measures the effect of *foreign executives* on innovation through R&D. In this case, the variable exhibits significant behaviour with the expected sign in all the models presented. In addition, it is the variable that has a higher impact (larger marginal effect). Overall, the results support Hypothesis 1a. Therefore, the employment of executives from different nationalities increases the likelihood of devoting a significant amount of resources to R&D activities, which in turn influences firm growth. Similarly, the results support Hypothesis 1b, as it also has a significant and positive sign in all the models presented. Therefore, the higher the percentage of employees with *fixed-term contracts*, the more likely it is that R&D activities will be developed; however, this impact is less relevant than in the case of the previous hypothesis.

Labour regulations have a significant effect with the expected sign in Models 1 and 2; hence, the stronger labour market regulations are, the less likely it is that firms will engage in R&D activities (and vice versa). In addition, having appropriate labour market regulations also has an indirect effect on firm growth, as this variable also remains significant in Model 4. Overall, we find support for Hypothesis 2a. Hypothesis 2b addresses the role of *external training* in innovation through R&D. In this case, the fact that the employee receives formal training outside the firm has a positive impact on R&D activity (Models 1 and 2). Similarly, *external training* also affects firm growth indirectly through its significant effect in Model 4. Consequently, the findings also support Hypothesis 2b.

4.2. Robustness check

We performed several robustness checks to establish whether our previously reported results still hold in the face of a different set of variables, as well as different econometric techniques. In particular, as noted earlier, we conducted the same model, employing four identification

strategies. All these methodologies allow us to determine that the magnitudes and relationships remain stable across models and equations with little differences in either estimations or standard errors. The same occurs when the simultaneous models are assessed including a different set of variables. Comparing these models with those with all variables, the results hold.

In terms of the different methods used, Models 1, 2 and 4 in Table 5 correspond with the results derived from running the simple linear probability model through OLS regressions, the discrete choice model (probit), and the simultaneous equation model also using probit (Eq. 1) and OLS (Eq. 2). Even though OLS regressions are inappropriate in our setting, the estimated coefficients associated with *foreign executives*, *fixed-term contracts*, *labour regulations* and *external training* are still economically and statistically significant. In addition, for Models 3 and 4 in Eq. (2), the variable *innovation through R&D* is tighter and the estimated coefficients seem very stable across these regressions. It is reassuring that these coefficient estimates are in the middle range of the corresponding estimated coefficients presented in Models 1–3.

Regarding the different set of variables, an important observation is that both the company and environmental variables analysed seem to have high predictive powers regarding R&D activity and subsequent firm growth. Also, it is noteworthy that the coefficients remain similar in the presence of country fixed effects.

The findings from the checks described above show that our results are stable across various changes applied to the original specification. Therefore, we are confident that the company and environmental variables we studied had a robust positive effect on R&D activity and, subsequently, on firm growth.

5. Discussion and conclusions

Using data from the EU-EFIGE/Bruegel-UniCredit dataset for seven different European countries, this research studied the simultaneous effects that a set of factors (at the company and environmental levels of analysis) has on R&D activity, which may explain firm growth.

Particularly, the significant result of the variable *foreign executives* is in line with those studies that describe how foreign managers with different backgrounds have the potential to enhance the company's ability to adapt to changes or to identify new business opportunities (Li et al. 2012). In addition, aside from the direct effect on R&D, the results show that the presence of foreign executives has an indirect effect on firm growth. Hence, employing managers with different profiles and origins could contribute to the acquisition of new knowledge for the company (Andersen and Bettis 2015) which in the longer term has a positive effect on firm performance. In fact, companies increasingly rely on multidisciplinary and diverse R&D teams, because this may provide greater cognitive ability (Talke et al. 2010). Overall, diversity in the team is a valuable strategy and asset for companies, although, in some specific cases, excessive heterogeneity among the managerial team could be detrimental to team cohesion and to members' commitment to the group, which has a negative impact on R&D performance (Garcia-Martinez et al. 2016).

The results for the variable *fixed-term contract* show that having a significant number of temporary jobs has a positive effect on the development of innovative activities in established companies. More flexible companies (in terms of workforce) can have more efficient responses to external shocks (Krishna et al. 2015). Those firms with less flexible labour forces might tend to focus on relatively secure goods so that they do not have to pay the costs of adjusting the labour force (Di Cintio and Grassi 2017; Saint Paul 2002); hence, they may focus on incremental innovations rather than on launching completely new products and innovations (Aparicio et al. 2016).

From the perspective of the external formal institutional environment, the previous literature has already highlighted how regulations and certain procedural requirements can have a negative effect on innovation (Djankov et al. 2002; Johnson et al. 2015). In the case of the labour market, it is generally agreed that the fewer the restrictions, the more likely it is that companies will be able to attract the appropriate human capital resources for their new projects (Urbano et al. 2019b). Therefore, the significant effect of the variable *labour regulations* might have direct implications for policy makers supposed to foster R&D investments and innovation. According to our results, more simplified labour market regulations could have a direct influence on the development of R&D activities. Similarly, the simultaneous model presented shows that this could have an indirect effect on the growth of firms. Related to this, the influence of labour market flexibility on R&D has been extensively studied; however, previous research does not agree on the sign of this effect (Kleinknecht et al. 2014).

Finally, regarding the role of *external training,* the findings show that knowledge gives individuals greater cognitive capacity, making them more productive and efficient (Becker 1964). Formal education is considered to be one component of human capital that may assist in the accumulation of explicit knowledge and may provide skills useful to employees (Davidsson and Honig 2003); hence, individuals with a greater quality of human capital and education will be better able to identify and exploit business opportunities (Gonzalez and Solis 2011). In addition, successful innovation often requires highly qualified employees with specific skills; hence, both policy makers and companies should invest in training initiatives to foster R&D (Bornay-Barrachina et al. 2012).

Overall, this article has both theoretical and practical implications. The research provides a two steps model of the phenomenon of innovation through R&D because it simultaneously studies both its antecedents and consequences for firm growth in terms of number of

employees. This provides an enhanced understanding of the relevance of R&D determinants. This is, we contribute by showing a picture that includes not only how some key factors condition R&D investments but also how these factors lead to firm growth (Crepon et al. 1998). Hence, the importance of these specific determinants is reinforced. Our findings contribute to the research that highlights the challenges of understanding when investments in innovation and R&D actually lead to better firm performance (Markham et al. 2010). A significant part of the resources spent in R&D and innovation do not lead to better productivity or financial performance (Graddy-Reed et al. 2017), and therefore could be used more efficiently. In addition, the results also contribute to the discussion about the role of internal and environmental factors for R&D activities (Urbano et al. 2019a). Previous research in the area of management, had rarely emphasised the importance of the formal institutional context (North 1990) what limits our understanding of the factors that enable successful R&D investments. The findings of this study show how factors external to the company (labour regulations and access to well-trained employees) play a fundamental role. Overall, this contributes to those studies that rely on institutional economics (North 1990) to explain that innovation cannot be understood without considering the effect of the external context in which it takes place (Martin 2016). Finally, the findings also have practical implications, because an enhanced understanding of the effect of a set of factors on R&D activity and firm growth might be relevant, especially for those managers who are interested in implementing new innovative projects in their companies. Similarly, the relevance of the formal environment implies that the results could also provide relevant information for policy makers in the areas of entrepreneurship and innovation.

This research has some limitations and suggests some future research lines. First, more accurate proxies for both our dependent and our independent variables could be used. In

addition, following previous research, we differentiated our independent variables in terms of internal and environmental conditioning factors. Future studies could use other proxies, so that the differences between both types of variables are even more evident. Second, we used data for the years 2007-2009 but we did not take into account the effect of time. This is, although the data includes information for different years, it was collected in one single moment (cross-section), what limits the quality of the data studied. This implies that we are unable to capture how some of the companies' past actions influence the current R&D and growth practices. In addition, some European countries were affected by the economic crisis at the end of 2008, which may have influenced R&D investments in companies. However, Aristei et al. (2017) and Carboni and Medda (2018) explain that the EFIGE database works with mean values during the period spanning from 2007 through 2009. To some extent, the purpose of this treatment is to overcome possible biases due to the downturn lived in Europe. In this regard, our findings provide an enhanced understanding about how and to what extent R&D activities were affected by the economic crisis. Third, the significant role of some of the control variables (gender, age and type of industry, for instance) suggests that these issues could be developed further in future studies. For instance, individual entrepreneurship literature has extensively focused on the role of gender when developing entrepreneurial activities (Bardasi et al. 2011). However, to our knowledge, this issue has been much less researched in R&D literature. Fourth, the literature on R&D and firm growth has introduced a distinction between different type of growth as a relevant explanatory factor (Coad and Rao 2008), however, we only focus on growth in terms of number of employees. Future studies using more varied and wide-ranging datasets should account for this.

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